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PROVISIONAL INTELLIGENCE REPORT

THE PHOSPHORUS INDUSTRY OF THE USSR

CIA/RR PR-35

24 July 1953

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(ORR Project 80-51)

THE PHOSPHORUS INDUSTRY OF THE USSR*

Summary

The USSR seems to be self-sufficient with respect to the supply of both phosphorus and the raw material for phosphorus, phosphate rock (calcium phosphate). The Russians would have sufficient phosphorus available for large-scale munitions-filling and for the manufacture of nerve gases and do not seem to be vulnerable to economic warfare in this field.

There are two forms of elemental, or pure, phosphorus: white phosphorus and red phosphorus. Red phosphorus, which is used primarily in the manufacture of matches, is obtained by subjecting white phosphorus to elevated temperatures. White phosphorus, the main subject of this report, is by far the most important from both a military and an industrial point of view.

For strictly military purposes, white phosphorus is used primarily as a smoke-producing and incendiary agent. Phosphorus produces one of the most effective screening smokes known. Dangerous burns caused by burning phosphorus make it an efficient antipersonnel weapon. For these military uses, white phosphorus, either alone or in combination with other chemicals, is used as a fill in shells, bombs, and grenades. White phosphorus also is used in the preparation of the highly toxic nerve gases, such as Sarin and Tabun, which were developed by the Germans during World War II; in pyrotechnics; and in tracer compositions.

Soviet military requirements for phosphorus in 1952 are believed to have amounted to 9,900 metric tons, or 27.9 percent of total available production. Of this amount, 7,000 metric tons, or 19.7 percent, are believed to have been used for munitions-filling, tracer shells, smoke boxes, and flares and 2,900 metric tons, or 8.2 percent, for the manufacture of nerve gases.

The principal industrial uses for white phosphorus are as a raw material to be used in the production of phosphoric acid, phosphorus pentoxide, and phosphorus trichloride. From these intermediate chemicals, there are derived in turn a large number of other important phosphorous compounds. These last are used in the manufacture of foods, drugs, detergents, and plastics and in other branches of the chemical industry.

Total Soviet production of phosphorus in 1953 is estimated to be about 35,500 metric tons (between 25,500 and 48,900 metric tons). On the basis of this estimated production of phosphorus, the USSR ranks second only to the US among principal phosphorus-producing countries. In 1952, Soviet production was, however, equivalent to only about 20 percent of US production.

* This report contains information available as of 1 March 1953.

Soviet industrial requirements for phosphorus in 1952 are estimated to have amounted to 25,600 metric tons, or 72.1 percent of total available production. Of this amount, 23,040 metric tons, or 65.0 percent, were used in the manufacture of phosphoric acid; 1,360 metric tons, or 3.8 percent, in the manufacture of phosphorus pentoxide and phosphorus trichloride; and 1,200 metric tons, or 3.3 percent, to produce red phosphorus for use in the match industry.

The electrothermal method is the method generally used both in the US and in the USSR for the production of white phosphorus. This method involves the heating of a mixture of phosphate rock, coke, and sand in an electric-arc furnace.

Although Soviet technology is generally similar to that used in the US, the consumption of phosphate rock and of electric power per ton of phosphorus appears to be considerably higher in the USSR than in the US.

Total reserves of phosphate rock available in the USSR are believed to amount to 9 billion metric tons. The USSR is therefore assured of abundant supplies of this raw material for its production of phosphorus. Phosphate rock deposits are fairly evenly distributed west of the Urals and in Central Asia. The largest and richest deposits occur in the northern Kola peninsula and in the Kara-Tau range of South Kazakhstan.

The principal phosphorus-producing plants in the USSR are located in 5 economic regions* -- 1 plant at Kirovsk in the Northwest (Ia), 1 at Beketovka in the Volga (VI), 1 at Dzerzhinsk in Central European USSR (VII), 1 at Berezniki and 1 at Pervoural'sk in the Urals (VIII), and 1 at Alga in Kazakh SSR (Xa). Although it is not known where the Russians have reassembled the former Piesteritz phosphorus plant which was removed from East Germany, the equipment of this plant was reported by one reliable source to have been consigned to Sverdlovsk, Magnitogorsk, and Stalinsk.

Input requirements of raw materials and electric power necessary to achieve an annual production of 35,500 metric tons of phosphorus are estimated to be as follows: 440,000 metric tons of phosphate rock, 89,000 metric tons of silica, 71,000 metric tons of coke (67,000 metric tons of anthracite coal), 885 metric tons of carbon electrodes, and 640 million kilowatt-hours of electricity.

Transportation of phosphate rock to the producing plants probably does not constitute a problem, since most plants have either local or relatively nearby deposits of phosphate rock at their disposal. Shipment of white phosphorus under water is probably taking place by rail, truck, and ship, but it is doubtful that the Russians are able to ship much phosphorus over long distances, in view of the hazardous nature of the product and the special tank cars required.

* The term region in this report refers to the economic regions defined and numbered on CIA Map 12048, 9-51, USSR: Economic Regions.

Little is known concerning trade in phosphorus between the USSR and foreign countries. During World War II the USSR received shipments of 2,089 short tons of phosphorus. No other information concerning imports of phosphorus by the USSR is available. Only small amounts of phosphorus have been exported, mostly to East Germany, during the past 4 years.

There is no good evidence that phosphorus is being directly stockpiled in the USSR. Phosphorus-filled munitions at munitions-filling installations may, however, constitute a reserve stockpile of undetermined size, available for military operations.

Supplies of phosphorus probably could be restricted only by attack on the producing installations or their power plants.

I. Introduction.

A. Description of Phosphorus.

Phosphorus occurs in white and red allotropic forms. The most commonly known and most widely used is the white form, with which this report mainly deals. White phosphorus is a soft, translucent material, having a disagreeable, pungent odor. It is highly poisonous and burns spontaneously in contact with air, producing thick white fumes of phosphorus pentoxide (P_2O_5). White phosphorus has a density of 1.8, a melting point of 44°C, and a boiling point of 280°C. Since white phosphorus oxidizes rapidly in the air under spontaneous combustion, it is usually stored and handled under water. White phosphorus is soluble in carbon disulfide, benzene, chloroform, and toluene.

When white phosphorus is heated above 275°C for a prolonged period of time, it is converted to red phosphorus, a stable, noninflammable, and nonpoisonous product, which is not soluble in organic solvents.

B. Uses of Phosphorus.

1. Military.

The primary military use of white phosphorus is as a smoke-producing and incendiary agent. Phosphorus, when in contact with air, produces one of the most effective screening smokes known. The dangerous burns caused by burning phosphorus make it an efficient antipersonnel weapon. For these purposes, phosphorus is used as a fill in shells, bombs, and grenades either alone or in combination with other chemicals, such as sulfur or carbon disulfide.

The Russians made extensive use of white phosphorus in incendiary shells during World War II. Phosphorus, either alone or in solution, was used by the Russians as a filling for hand grenades, rifle shells, glass ampoules, incendiary flasks and projectiles, aerial bombs, rocket missiles, airborne incendiary apparatus, aerial ampoules, and rotational scatter bombs. 1/* Solutions of phosphorus in organic solvents were used chiefly as fillings for incendiary flasks for use against tanks. The most common solution was a saturated solution of white phosphorus in carbon disulfide, with or without an admixture of crude turpentine.

White phosphorus also is an essential ingredient of the highly toxic nerve gases, known as Tabun and Sarin, which were developed by the Germans during World War II. It was used in the proportion of 0.24 metric ton per metric ton of Tabun and 1 metric ton per metric ton of Sarin. Phosphorus also is used in making pyrotechnic mixtures, such as tracers and flares. Red phosphorus is used as a component of tracer and incendiary mixtures and also in chemical warfare as a component of match heads for igniting smoke boxes and friction primers (airplane flares).

2. Industrial.

White phosphorus is the basic starting material in the manufacture of a large number of phosphorous compounds, of which the most important are phosphoric acid, phosphorus pentoxide, and phosphorus trichloride. These key compounds derived from phosphorus are in turn converted to many other derivatives, some of the most widely used of which are fertilizers; nutritive and therapeutic agents; reagents in organic syntheses and in the production of antibiotics, antimalarials, and sulfa drugs; water-softening and ore-flotation agents; detergents; oil additives; fire-resistant and anticorrosion compounds; plasticizers (tricresyl and triphenyl phosphates); soft drinks; baking powder; and dentifrices. Phosphoric acid, or some other derivative of phosphorus, is used in at least one step of the manufacturing process of most industries: for instance, in the drugs, leather, paper, brewing, cellulose, dye, printing, rubber, and soap industries; in the manufacture of high-octane gasoline; in the pickling of stainless steels; in the bright dipping of aluminum; and in the rust proofing and metal bonding of metal surfaces.

Red phosphorus is of lesser industrial importance than white phosphorus, and is used primarily in the match industry as a component of the mixture applied to the striking surface of match boxes, and also in the preparation of phosphor bronzes.

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* Footnote references in arabic numerals are to sources listed in Appendix D.

C. Production Methods.

1. White Phosphorus.

a. Electrothermal Method.

The electrothermal is the most important and most generally used method throughout the world for the production of white phosphorus. A mixture of phosphate rock (mainly calcium phosphate), coke or anthracite coal, and silica is placed in an electric-arc furnace, where, in the intense heat of the electric arc (1,300 to 1,500°C), the phosphate rock is reduced by the carbon of the coke to phosphorus and slag. The liberated phosphorus in vapor form together with carbon monoxide and other gases, passes into coolers where the pure phosphorus is collected and is kept under water until solidified into cakes or sticks, which are then shipped or stored under water in tins or barrels.

The electric-arc furnaces usually operate on single-phase or three-phase current and are provided with carbon or, in some cases, with graphite electrodes. They are similar to calcium carbide ovens except that they are hermetically closed to prevent entry of air, which would oxidize the phosphorus into phosphorus pentoxide. Three-phase electric-arc furnaces generally are considered to be more practical and more powerful and are the ones most often installed at present. The main structure of the furnaces is boiler plate. The furnaces are lined with asbestos, with fire-resistant clay, with a mixture of coal and pitch, or with graphite and pitch.

Early furnaces for the production of phosphorus were quite small and were for a batch type of operation. Improved technology has led to larger, continuously operated furnaces. Many plants now have capacities of 10 to 25 metric tons of phosphorus per day. Some plants find it economical to operate only 1 furnace, whereas others may have 3 to 5 furnaces in operation.

Careful chemical control is a necessity in the operation of electric-arc furnaces. Slight changes in the ratio of the various raw materials or in their composition may result in serious losses. Grinding and mixing of the raw materials are necessary to achieve good results. At some plants the materials are first fused into briquettes.

Apatite and phosphorite ores are the most commonly used phosphate rock raw materials. Silica, in the form of sand or quartz, or in the form of silicates such as nepheline or feldspar, is added as a flux. This facilitates the reduction of the phosphate rock and converts the calcium oxide into stable, low-melting calcium silicate, forming a slag which can be easily removed from the furnace. The proportion in which the various ingredients are used varies according to the chemical analysis of different batches of raw materials. The amount of coke used in such as to provide a 10-percent excess of carbon.

The electric power capacity of single-phase electric-arc furnaces does not exceed several hundred kilowatts (kw), and that of three-phase furnaces ranges up to 12,000 kw. According to Soviet practice the average electric power consumption required for the production of 1 metric ton of phosphorus is reported to vary between 16,000 and 20,000 kilowatt-hours (kwh). 2/

The consumption of phosphate rock and electric power per metric ton of phosphorus appears to be considerably higher in the USSR than in the US. The yield of phosphorus, based on the calcium phosphate content of the phosphate rock, is about 92 to 95 percent in US practice but appears to be lower in the USSR. The comparable Soviet yield of usable phosphorus varies from between 70 to 85 percent of the total phosphorus content of the charge. 3/ Soviet phosphorus technology is generally similar to that practiced in the US.

b. Blast-Furnace Method.

The blast-furnace method for the production of white phosphorus is of secondary importance and generally is not considered economical or practical in view of the low yield of phosphorus obtained. Research studies on this process have been under way, however, both in the US and in the USSR, aimed principally at the production of phosphoric acid from the phosphorus obtained in this manner. The blast-furnace method was tested in the USSR in pilot-plant operation but has not been used industrially, mainly because of the high consumption of coke. Nevertheless, in 1944, because of the critical demand for phosphorus, the blast-furnace method was used in several Soviet plants, although the yield of phosphorus was low. 4/

A blast furnace similar in appearance and structure to the blast furnaces used in the steel industry is employed in this method. Phosphate rock is pulverized; mixed with ground coke; and compressed into briquettes, which, together with sand as a flux and additional coke, are charged into the top of the furnace. The high temperature required for the reduction of the phosphate rock to phosphorus is achieved by the combustion of the carbon content of the charge to carbon monoxide. The amount of coke added is therefore considerably larger than in the electric-arc furnace process. Blast air, required for the combustion of coke and liberation of heat, is introduced into the furnace after being preheated to 600 to 800°C in heat exchangers. The gases leaving the furnace have a low phosphorus content because of the high dilution with nitrogen introduced into the furnace as part of the blast air. About 25 percent of the phosphorus liberated in the blast furnace is converted to phosphine gas (PH_3) and is therefore lost. For these reasons, the recovery of phosphorus in liquid form by condensation is not economical. It is usually preferable to convert the phosphorus-containing gases to phosphorus pentoxide and then to phosphoric acid.

2. Red Phosphorus. 5/

Red phosphorus is obtained by heating white phosphorus in muffle ovens, autoclaves, or rotary drums, first to 275 to 280°C then gradually

raising the temperature over a period of several days to 330 to 340°C. According to Soviet practice, about 1.1 metric tons of white phosphorus are needed to produce 1 metric ton of red phosphorus. This conversion requires from 1.8 to 1.9 metric tons of heavy oil or 5,000 kwh of electric power for heating the reactors.

D. Historical Development of Soviet Production Methods. 6/

Small phosphorus-producing installations existed in Tsarist Russia. They were based on the retort method of reducing dicalcium phosphate, which was obtained by the action of sulfuric acid on bones. The first research studies on the electrothermal production of phosphorus were carried out in 1921-22 at the Scientific Institute of Fertilizers by S.I. Volfkovich and E. Tukovskiy. Further research and development of this process were done at the Leningrad Institute of Applied Chemistry (GIPKh) and by factory engineers.

The production of phosphorus by the electrothermal method was established in 1928. The first Soviet electric-arc furnaces for full-scale electrothermal production of phosphorus from domestic phosphorites were constructed at the Chernorech'ye Chemical Combine imeni Kalinin at Dzerzhinsk and were developed by S.I. Volfkovich, who was awarded the Mendeleyev prize in 1931 for his work on phosphorus and phosphates.*

The USSR has never published figures concerning the production of phosphorus. The earliest reported figure of phosphorus production is for the year 1923-24, when, according to a very doubtful and unconfirmed source, about 2,000 kilograms (kg) of phosphorus were produced at the Troitsk phosphorus factory in Zolotaya Sopka, Chkalov Province, in the Urals. This factory is said formerly to have produced glue, various soaps, and red phosphorus. It is not known whether this plant is still in operation. Production of unknown quantities of phosphorus by the Leningrad Institute of Applied Chemistry, formerly known as the Vatny Ostrov Chemical Plant, was reported in 1928 and 1929.

The first plant for the electrothermal production of phosphorus in the USSR, equipped with 1 three-phase electric-arc furnace operating on a 2,000-kw current, was stated to have begun production in 1933 in the Khibiny mountains near Kirovsk on the Kola peninsula.** During the period 1927-37, production of phosphorus in the USSR reportedly increased several times

* See Appendix A, Plant C, p. 22, for further information.

** See Appendix A, Plant D, p. 24, for further information.

tenfold. This increase in production was undoubtedly connected with the exploitation of the huge phosphate rock (apatite) despoits of the Khibiny tundra, where production of phosphorus was contemplated as early as 1932.

The exact production of phosphorus before and during World War II is not known. It has been stated that the USSR suffered a severe shortage of this chemical during the war. Shipments of 2,089 short tons of phosphorus from the US to the USSR under Lend-Lease attest to this shortage.

II. Supply Situation.

A. Ore Deposits.

The principal phosphate rock deposits in the USSR include the apatite deposits located in the Khibiny mountains near Kirovsk on the Kola peninsula; the phosphorite deposits located in the Kara-Tau range, extending through Dzhambul Oblast and South Kazakhstan Oblast, and phosphorite deposits located in Aktyubinsk Oblast of Kazakh SSR; in Kirov Oblast (area of the Vyatka-Kama deposits) and in the Moscow (Yegor'yevsk), Orël, and Kursk oblasts. 7/

The total currently known ore reserves of phosphate rock in the USSR are estimated at 9 billion metric tons. These are primarily apatite and phosphorite, both of which consist of calcium phosphate and various other minerals. Of this amount, less than 2 billion metric tons are classified as explored (proved) reserves. The ore varies from 12 to 30 percent in content of phosphorus pentoxide.

The total ore reserves of apatite, as of January 1938, were reported as 2 billion metric tons, of which nearly 500 million metric tons were classified as explored reserves. The content of phosphorus pentoxide in the apatite ore varies from 24 to 28 percent.

The total known ore reserves of phosphorite, as of January 1938, were given as 6 billion metric tons, of which more than 1 billion metric tons were classified as explored reserves. The content of phosphorus pentoxide in the phosphorite ore varies from 12 to 30 percent. 8/ A more recent report indicates an increase of 1 billion metric tons in the total ore reserves of phosphorite, with a content of 30 percent phosphorus pentoxide. 9/

Both apatite and phosphorite ores are concentrated principally by flotation methods. In the manufacture of phosphorus the purity or grade of the ore is not so important as in the preparation of fertilizers, such as superphosphate. The highest grade of phosphate rock in the USSR is the apatite concentrate from the deposits in the Khibiny mountains, followed by the phosphorite concentrates from the Kara-Tau range of South Kazakhstan. Table 1* shows the content of phosphorus pentoxide in ore and concentrates from the principal phosphate rock deposits in the USSR. 10/

* Table 1 follows on p. 9.

Table 1

The Phosphorus Pentoxide Content of
Principal Phosphate Rock Deposits in the USSR

Area	Type of Ore	Product	Percent of Phosphorus Pentoxide Content
Khibiny	Apatite	Ore	20.8 to 34.6
		Concentrate	38.8 to 40.2
Kara-Tau	Phosphorite	Ore	26.2 to 30.0
		Concentrate	
Vyatka	Phosphorite	Ore (Washed)	23.5 to 26.0
		Concentrate	28.0 to 28.3
Yegor'yevsk	Phosphorite	Ore	21.2 to 23.7
		Concentrate	27.5 to 31.0
Aktyubinsk	Phosphorite	Ore	17.5 to 19.0
		Concentrate	25.0 to 26.0

B. Supply of Phosphorus.

1. Production Estimates.

Soviet plants were probably producing phosphorus in 1952 at an estimated total annual production rate of about 17,500 metric tons.* In addition, 18,000 to 20,000 metric tons of annual capacity for the production of phosphorus were dismantled from the German Piesteritz plant in 1946 and were removed to an unknown destination in the USSR.**

Assuming that the Piesteritz furnaces are now installed and operating in the USSR, total Soviet production of phosphorus in 1952 can be estimated at about 35,500 metric tons annually. The true figure probably lies between 25,500 and 48,900 metric tons. This wide range has had to be given because of the many uncertainties existing in the information available on the production of individual plants and because of the total lack of information regarding Soviet requirements for phosphorus.***

The position of the USSR in relation to other phosphorus-producing countries is shown in Table 2.****

* A Soviet engineer who dismantled the installations producing phosphorus at Bitterfeld in East Germany stated that there were 5 plants producing phosphorus in the USSR, 1 of which was located on the Kola peninsula. 11/

** The Piesteritz plant was reported by one reliable source to have been consigned to Sverdlovsk, Magnitogorsk, or Stalinsk. 12/

*** See Appendix B for full discussion of the methods which were used in arriving at the above estimates.

**** Table 2 follows on p. 10.

Table 2

Estimated Production of Phosphorus by Selected Countries
1952

Metric Tons

Country	Amount
US	180,000
USSR	35,500 a/
UK	18,000 a/
France	12,000
West Germany	4,500 a/

a. CIA estimates.

2. Imports and Exports. 13/

Little information is available regarding imports of phosphorus by the USSR. An unconfirmed report of 1951 from the Electrochemical Combine Bitterfeld in East Germany stated that the deliveries of phosphorus to the USSR leave there as priority shipments via Stettin with no indication as to destination. This information is contradicted by reports of 1951 exports of phosphorus from the USSR to East Germany.

If production of phosphorus in East Germany increases beyond that country's most urgent requirements, it is possible that shipments of phosphorus to the USSR may eventuate. Other than the USSR, East Germany is the only known producer in the Soviet Bloc.

Scattered information is available on exports of phosphorus from the USSR during the years 1948-51, indicating shipments of relatively small amounts, principally to East Germany and Finland. Finland reportedly received 10.5 metric tons in 1949. Soviet exports of phosphorus to East Germany were apparently about 600 metric tons in 1948, 600 metric tons in 1949, 20 metric tons in 1950, and about 100 metric tons in 1951. It therefore seems probable that Soviet exports of phosphorus to East Germany will either drop to a negligible amount or even cease completely during and after 1952. Production of phosphorus in East Germany is rapidly increasing and will probably make this country independent of imports from the USSR.

3. Stockpiles. 14/

There is no good evidence that phosphorus is being stockpiled by the USSR in bulk form. It is known that the Russians seized 5,000 metric tons of phosphorus stored by the Germans in their Dyhernfurth nerve-gas factory, which fell into Soviet hands in 1945. Machinery and equipment from the Dyhernfurth factory were dismantled by the Russians and were reported to have been delivered to Beketovka, near Stalingrad. It is quite conceivable that these 5,000 metric

tons of phosphorus were also transported to Beketovka and possibly were stored there. Several reports mention shipments of phosphorus in German tank cars arriving at Beketovka. It is known that phosphorus munitions-filling installations were operating, at least to a limited extent, in the years immediately following World War II. It seems probable that these installations are still operating.

The Russians undoubtedly do possess a stockpile of undetermined size of phosphorus-filled munitions.

4. Total Supply.

Exclusive of possible stockpiles, the total 1952 supply of phosphorus available to the USSR is estimated at 35,500 metric tons (somewhere between 25,500 and 48,900 metric tons).

C. Input Requirements.

1. Primary Raw Materials. 15/

The amounts of raw materials required for the production of 1 metric ton of phosphorus, according to Soviet practice, are shown in Table 3.

Table 3

Raw Materials Required for the Production of 1 Metric Ton of Phosphorus in the USSR

Raw Material	Metric Tons Amount a/
Phosphorite	11 to 16.5 b/
or	
Apatite	9 to 16
Silica	2.5
Coke	2.0
or	
Anthracite Coal	1.9

a. Approximate.
b. Depending on composition.

The manufacture of 35,500 metric tons of phosphorus, the most probable estimate of production in the USSR in 1952, would therefore require the quantities of raw materials shown in Table 4.*

* Table 4 follows on p. 12.

Table 4

Raw Materials Required for the Production of 35,500 Metric Tons of Phosphorus in the USSR

	Metric Tons
Raw Material	Amount a/
Phosphate Rock	444,000 b/
Silica	89,000
Coke	71,000
or	
Anthracite Coal	67,000
Carbon Electrodes	885 c/

a. Calculated from Table 3.
b. Based on an average consumption of 12.5 tons of phosphate rock per metric ton of phosphorus.
c. No information was available on Soviet consumption of carbon electrodes in the production of phosphorus. Therefore, in accordance with US practice, a factor of 50 pounds of carbon electrode material per ton of phosphorus was used in this calculation.

2. Electric Power. 16/

Power consumption depends on the type of furnace and on the phosphorus pentoxide content of the phosphate rock and varies from 16,000 to 20,000 kwh per metric ton of phosphorus. Soviet consumption of electric power in 1952 for the manufacture of 35,500 metric tons of phosphorus, therefore, is estimated at about 640 million kwh, using an average of 18,000 kwh per metric ton of phosphorus.

D. Plant Locations and Capacities.

Table 5* lists the locations and estimated annual capacities of known and probable phosphorus plants in the USSR.**

* Table 5 follows on p. 13.
** See Appendix A for further information about these plants.

Table 5

Locations and Estimated Capacities of Phosphorus Plants in the USSR
1952

Metric Tons

Location	Plant Name	Annual Capacity a/
Northwest (Ia)		
Kirovsk	Apatite Chemical Combine	5,000
Volga (VI)		
Beketovka	Factory No. 91	2,700 to 7,600
Central European USSR (VII)		
Dzerzhinsk	Chernorech'ye Chemical Combine imeni Kalinin	4,800
Urals (VIII)		
Berezniki	Voroshilov Chemical Combine	4,500
Pervoural'sk	"Desyatiletiye Oktyabrya" Khrompik Chemical Combine	500 to 5,000
Kazakh SSR (Xa)		
Alga	Aktyubinsk Chemical Combine imeni Kirov	0 to 2,000

a. 18,000 to 20,000 metric tons of additional annual capacity (4 furnaces) were dismantled in 1946 from the German Piesteritz plant. The location of these furnaces in the USSR has not been determined.

E. Transportation.

1. Phosphate Rock. 17/

Little positive information is available as to the sources and routes of transportation of phosphate rock to each of the individual plants producing phosphorus listed in Table 5. All but one of the known phosphorus-producing plants in the USSR are located in geographic areas having either

local or relatively close phosphate rock deposits capable of supplying phosphate rock by rail or by water. Transportation of phosphate rock from the mines to the consuming plants depends primarily on the availability of freight cars and offers no particular problem. One source states that Soviet freight cars handling phosphates have a capacity of approximately 40 metric tons of apatite each.

The one plant which is dependent on long-distance transportation of phosphate rock is the Bekstovka plant near Stalingrad. This plant is believed to receive part of its phosphate rock from the large Kara-Tau deposits in South Kazakhstan, which would involve a 1,000 to 1,500 - mile haul by railroad and possibly by barge across the Caspian Sea from Krasnovodsk and up the Volga River. Shipments of phosphate ore to this plant by barge, boat, and rail have been reported. It is possible that the Bekstovka plant may also receive apatite from the Kola peninsula, and phosphorite from deposits in Yegor'yevsk in Central European USSR (VII), in Kirov Oblast in the Vyatka-Kama area, or in Aktyubinsk Oblast. Difficulty in transportation of raw phosphate rock therefore could affect the production of phosphorus at this plant.

It is known that the Apatite Chemical Combine at Kirovsk utilizes local apatite deposits as raw materials for its production of phosphorus and that the plant at Alga has its own phosphorite mines. No transportation problems, therefore, arise in connection with these two plants.

Phosphate rock shipped to the Chernorech'ye Chemical Combine imeni Kalinin at Dzerzhinsk is reported to consist of phosphorite from Vyatka, Yegor'yevsk, and Saratov and of apatite from the Kola peninsula. These deposits, with the exception of the Kola apatite, are located within a few hundred miles of the plant. Shipments of phosphate rock by rail to this plant, therefore, probably present no problem.

The Voroshilov Chemical Combine at Berezniki is reported to receive phosphate rock from the nearby Vyatka (Kirov) area. Although no information is available as to the origin of the phosphate rock utilized by the "Desyatiletiye Oktyabrya" Khrompik Chemical Combine at Pervoural'sk, which also is located in the Urals area, it is probable that this plant also receives its phosphate rock from the Vyatka-Kama deposits.

2. Phosphorus. 18/

Transportation of phosphorus is by rail and by truck. The phosphorus is placed in tank cars, barrels, drums, earthenware jars, or even kettles, under a protective layer of water or calcium chloride brine. Phosphorus may also be transported in the form of phosphorus-filled munitions, such as shells, bombs, and grenades, which can be filled at the producing plants. Both the filling of phosphorus into munitions and the shipment of these filled munitions by rail and truck for use by the Soviet Army and Navy

are known to take place at some Soviet phosphorus plants. The transportation of phosphorus over long distances is a hazardous job, requiring fire precautions. For this reason, it is considered doubtful that much phosphorus is shipped as such over long distances* in the USSR. It appears more likely that phosphorus is transported in the form of filled munitions.

III. Requirements.

No information is available concerning Soviet military or industrial requirements for phosphorus. Likewise, quantitative information concerning Soviet output of products derived from phosphorus is entirely lacking. This precludes any calaculation of requirements from such sources. Therefore, in attempting to establish at least a probable pattern of Soviet requirements, it has become necessary to make some rather broad assumptions. Statistics concerning US requirements for phosphorus were used as a guide in estimating Soviet requirements.

A. Military.

Table 6 shows the estimated Soviet military requirements for phosphorus in 1952.

Table 6

Estimated Soviet Military Requirements for Phosphorus
1952

Use	Amount Required (Metric Tons) a/	Percent of Total
Munitions-Filling, Tracer Shells, Smoke Boxes, Flares, and Other Fillings	7,000	19.7
Nerve Gases	2,900	8.2
Total	9,900	27.9

a. Estimated. See Appendix C for the method used in making these estimates.

* The bulk of this information relating to shipments of phosphorus came from a study of the activities at Factory No. 91 at Beketovka and the Chernorech'ye Chemical Combine imeni Kalinin at Dzerzhinsk.

B. Industrial.

Table 7 lists the probable amounts of phosphorus needed to make key phosphorus compounds for industrial purposes. Because of lack of Soviet data, these amounts were calculated on the basis of US experience.*

Table 7

Estimated Soviet Industrial Requirements for Phosphorus
1952

Use	Amount Required (Metric Tons) a/	Percent of Total
Phosphoric Acid	23,040	65.0
Phosphorus Pentoxide or Phosphorus Trichloride	1,360	3.8
Matches	1,200	3.3
Total	25,600	72.1

a. Estimated. See Appendix C for the methods used in making these estimates.

IV. Capabilities, Vulnerabilities, and Intentions.

A. Capabilities.

As noted in Table 2,** the USSR occupies second place in world production of phosphorus, probably producing almost 20 percent as much as the world's leading producer, the US. If 35,500 metric tons, the estimate of annual production given in this report, is reasonably accurate, it then appears that the USSR has sufficient phosphorus for such large-scale chemical warfare purposes as munitions filling and the manufacture of nerve gases.

B. Vulnerabilities.

The USSR is not an importer of phosphorus, being self-sufficient with respect to production of both phosphate rock and phosphorus, and is therefore not vulnerable to economic warfare with respect to this chemical. Supplies of phosphorus could be restricted principally by attack on the producing installations or their power plants.

* See description of method on p. 36.
** P. 10, above.

C. Intentions.

Accurate knowledge concerning Soviet supplies of phosphorus probably would not be an indicator of Soviet intentions. Until detailed information regarding allocations becomes available, it is doubtful whether any reasonable conclusions concerning Soviet intentions can be drawn from a study of the phosphorus industry alone.

APPENDIX A

PHOSPHORUS-PRODUCING PLANTS IN THE USSR

This appendix summarizes the known information about individual phosphorus-producing plants in the USSR. The known producers are listed in I, and other possible producers for which some information was found are listed in II.

For some of the plants listed in II, only partial names or no names at all were found.

I. Known Producers.

A. Factory No. 91.

1. Location.

Beketovka, Stalingrad Oblast, Volga (Region VI).

2. Estimated Production of Phosphorus in 1953.

2,700 to 7,600 metric tons per year.

3. Production Information.

a. Production of Phosphorus. 19/

The production of phosphorus at this plant is reported by many sources and is substantiated by reported shipments of phosphate rock to the plant. Several sources report deliveries of phosphate rock amounting to about 23,000 to 65,000 metric tons per year. It is not known which of these reports is the more accurate or what types of rock are delivered to the plant. Assuming, however, that a high-grade ore such as the one mined at Kara-Tau, which has an average phosphorus pentoxide content of about 28 percent, would be used by this plant, and assuming that all the ore delivered to the plant is used for the manufacture of phosphorus, the output of phosphorus, calculated from the reported deliveries of phosphate rock, would amount to about 2,700 to 7,600 metric tons per year.

b. Production of Other Phosphorous Compounds. 20/

Phosphoric acid production was reported by three sources. The production is said to have amounted to at least 5 tank cars per day shipped to unknown destinations or to 180 metric tons per month shipped in drums to Poland.

4. Military Activities.

This plant has reportedly filled phosphorus into the following munitions:

a. Grenades, including 8-cm, 12-cm, and 13-cm sizes. 21/

b. Bombs, including aircraft type and 25-kg, 50-kg splinter, and 250-kg detonation types. 22/

c. Shells, including 2.7-cm, 7.65-cm, 8.8-cm, 12-cm, and 17-cm antiaircraft; 10.7-cm artillery; and mortar shells of different calibers. 23/

d. Ammunition, 12.2-cm caliber. 24/

e. Smoke pots. 25/

f. Molotov cocktails (27 percent sulfur, 73 percent phosphorus). 26/

5. Plant Equipment.

The following equipment probably used in the production of phosphorus has been reported:

a. Smelting furnaces, including 2 three-phase electric-arc furnaces and 2 horizontal furnaces about 4 m long and 1 to 1.5 m in diameter, possibly oil-fired. 27/

b. Phosphorus ovens, reported to have been under construction during the period September 1948 to April 1949. 28/

c. One rotary furnace, probably for manufacture of red phosphorus, which was being dismantled and replaced in March 1949. 29/

d. Two barrel-shaped furnaces, about 3 m high and 3 m in diameter, which had not been used since 1945 but which were to be used in the future. 30/

e. Carbon electrodes, about 2 to 2.20 m long. 31/

f. One distillation apparatus of complicated structure. 32/

g. Six steel-sheet vessels, 6 m high and 2 to 3 m in diameter, probably for storage of liquid phosphorus. 33/

h. Four insulated steel tanks, 6 m high, 3 m in diameter, painted black, provided with many pipes. 34/

i. Several boilers. 35/

j. One quartz-crushing machine. 36/

k. Two stone breakers. 37/

l. Two grinding drums. 38/

m. One conveyor belt. 39/

n. Four phosphate crushers. 40/

6. Source of Power. 41/

Beketovka power plant, located opposite Factory No. 91, has its own transformer station and supplies an electric current of 60,000 to 70,000 volts to Factory No. 91 by means of an underground cable. The phosphorus plant is equipped with a large electric switchboard and a transformer station provided with four transformers.

7. Raw Materials.

a. Phosphate Rock. 42/

Several sources report the delivery of phosphate rock to this plant in barges on the Volga River. These sources indicate that the deliveries of phosphate rock amounted to about 23,000 to 65,000 metric tons per year.

b. Coke. 43/

Coke, limestone, and anthracite were reported to be used, and coal and coke were reported to be stored in large quantities.

c. Silica. 44/

No information other than the fact that quartz was used in the production process.

8. Storage of Phosphorus. 45/

Phosphorus is reported to be stored in the plant, both in a building and in tank wagons of 60-metric-ton capacity.

9. Distribution of Phosphorus. 46/

One source stated that the phosphorus produced by the plant was intended exclusively for the Soviet Army and Navy and that it was taken away by Soviet Army vehicles. The phosphorus was said to be shipped in metal barrels of 200-liter capacity, by truck only, to an unknown destination. Another source reported the shipment, at least twice a month, of a tank car of phosphorus to Leipzig.

B. Voroshilov Chemical Combine.

1. Location.

Berezniki, Molotov Oblast, Urals (Region VIII).

2. Estimated Production of Phosphorus in 1953.

4,500 metric tons per year.

3. Production Information.

a. Production of Phosphorus. 47/

The production of phosphorus at this plant is based on German intelligence reports of 1942 and 1943. This plant was considered by the Germans as being one of the largest Soviet chemical plants, which was reported to be producing chlorine, heavy chemicals, war gases, explosives, phosphorus, and smoke agents during the war. In the absence of more recent information, the German estimate of 4,500 metric tons per year is accepted.

b. Production of Other Phosphorous Compounds.

No information.

4. Military Activities.

No information.

5. Plant Equipment. 48/

The production units are reported to be mechanized and in part automatic.

6. Source of Power. 49/

One steam power plant, using coal dust as fuel, built by Borsig, produced 83,000 kw in 1936 and 105,000 kw in 1941. Another power plant, consisting of six turbines, operated hydraulically, is reportedly of most modern construction. In 1941 this power plant produced 450 million kwh during 5,000 operational hours. Branch stations receive their power from the main plant and from the Solikamsk-Gubakha network. Additional power comes from the plant at Solikamsk.

7. Raw Materials.

a. Phosphate Rock. 50/

Phosphorite from Vyatka (Kirov) on the Yar -- Fosforitnaya branch line.

b. Coke. 51/

From Gubakha.

c. Silica.

No information.

8. Storage of Phosphorus.

No information.

9. Distribution of Phosphorus.

No information.

C. Chernorech'ye Chemical Combine imeni Kalinin.

1. Location.

Dzerzhinsk, Gor'kiy Oblast, Central European USSR (Region VII).

2. Estimated Production of Phosphorus in 1953.

4,800 metric tons per year.

3. Production Information.

a. Production of Phosphorus. 52/

The production of both white and red phosphorus at this plant is substantiated by a report mentioning the construction at this plant of the first electric-arc furnaces for the production of phosphorus, as well as by numerous sources mentioning production of phosphorus since 1930 and up to 1949.

b. Production of Other Phosphorous Compounds. 53/

Production of phosphoric acid has been reported by at least three sources. This production for 1936 was reported as 24 metric tons daily Production of trisodium phosphate, ammonium phosphate, and other fertilizers was also reported.

4. Military Activities. 54/

The filling of phosphorus into incendiary bombs and mortar projectiles was reported to have taken place here during the war. One report mentions 30- to 50-kg phosphorus bombs and another report mentions bombs about 120 cm long and 50 to 60 cm in diameter.

5. Plant Equipment. 55/

The first Soviet electric-arc furnaces for full-scale electrothermal production of phosphorus from domestic phosphorites (developed by S.I. Volfkovich) were constructed at this plant.

6. Source of Power. 56/

The Chemical Combine is supplied with electric power from the following sources:

a. From its own power plant, built between 1934 and 1937, located on the Oka River, using peat as fuel and producing 50,000 kw of electricity.

b. From the Gor'kiy GRES I* Balakhna, which uses peat, coal, and crude oil as fuel and produces 204,000 kw of electricity.

c. From the power plants Balakhaninski TETS,** Dzerzhinsk TETS, and Gor'kiy TETS.

7. Raw Materials. 57/

a. Phosphate Rock.

Phosphorite is obtained from the Vyatka, Yegor'yevsk, and Saratov deposits; apatite from the Kola peninsula.

b. Coke.

No information.

c. Silica.

No information.

8. Storage of Phosphorus.

No information.

9. Distribution of Phosphorus.

No information.

Note: Besides production of phosphorus at this plant, there is some indication that phosphorus in unknown amounts may possibly be produced at the nearby Factory No. 96, also located at Dzerzhinsk.

* State Regional Electric Station No. 1.

** Thermoelectric Central Station

D. Apatite Chemical Combine.

1. Location.

Kirovsk, Murmansk Oblast, Northwest (Region Ia).

2. Estimated Production of Phosphorus in 1953.

5,000 metric tons per year.

3. Production Information.

a. Production of Phosphorus. 58/

The production of both white and red phosphorus at this plant is reported by several sources. It is known that an experimental plant for the production of phosphorus by the electrothermal method was built in this area as early as 1932, and in 1934 this plant was reported to be the largest phosphorus plant in the USSR. In 1940, Kirovsk was regarded as the center of the Soviet phosphorus industry. Although most of the information relating to phosphorus production at this plant is based on prewar reports, and no evidence of plant expansion or increased production in recent years is available, it seems very likely, in view of the abundant phosphate rock (apatite) reserves and electric power available in the area, that phosphorus is being produced at the present time at the rate of at least 5,000 metric tons per year.

b. Production of Other Phosphorous Compounds. 59/

Phosphoric acid, superphosphate, mixed fertilizers, and other technically important phosphoric acid compounds are reported to be produced at this plant. A production of 2,000 metric tons of phosphoric acid per year was planned at the time of the building of the plant.

4. Military Activities. 60/

During the war, Molotov cocktails were produced at this plant. Phosphorus was filled into various other types of canisters for the Soviet Army.

5. Plant Equipment. 61/

One three-phase electric-arc furnace, operating on a 2,000-kw current.

6. Source of Power. 62/

In 1934 the construction of the Nivskaya GES was completed. Before 1935 the operating capacity of the power plant was 15,000 kw. A 15,000-kw

turbine was put into operation in 1935. This plant supplies electric power both to the apatite mines in the Khibiny mountains and to the Apatite Chemical Combine. During the period 1932-39, two other large hydroelectric plants were also erected and put into operation in the Niva Valley.

7. Raw Materials.

a. Phosphate Rock. 63/

Apatite deposits discovered in 1921 in the Khibiny mountains, estimated at 2 billion metric tons, are the reported source of supply for this plant. Other large reserves of apatite are located further to the West, in the Monche tundra. The crude apatite contains 30 to 35 percent phosphorus pentoxide, and a concentrate of 38 to 40 percent phosphorus pentoxide is obtained by a magnetic and flotation process, which is used in the production of phosphorus. Some of the concentrate is processed near the deposits, and some is shipped to superphosphate plants in other parts of the USSR or is exported.

b. Coke. 64/

A peat-coking plant was reported under construction in 1935 near the Laplandiya railroad station. The primary purposes of this plant were (1) to supply peat tar to the apatite concentrating plant near the Apatity railroad station, where it was to be used as a flotation reagent, and (2) to supply the peat coke for phosphorus production at this plant.

c. Silica.

No information.

8. Storage of Phosphorus.

No information.

9. Distribution of Phosphorus.

No information.

II. Possible Producers.

In addition to the plants listed in I, above, for which evidence of actual or probable phosphorus production is available, there have been indications, from 1 or 2 and, in a few cases, from 3 or 4 or more sources each, that phosphorus may also be produced at the plants listed below. Because of the scant and unconfirmed information currently available, these plants should not be regarded at this time as more than possible producers of phosphorus.

A. Aktyubinsk Chemical Combine imeni Kirov.

1. Location.

Alga, Aktyubinsk Oblast, Kazakh SSR (Region Xa).

2. Estimated Production of Phosphorus in 1953.

0 to 2,000 metric tons per year.

3. Production Information.

a. Production of Phosphorus. 65/

Several sources reported the production of phosphorus at this plant during the period 1939-46, and one of these sources reported that phosphorus was produced on a large scale. None of these reports, however, gives any information concerning the actual output of phosphorus at this plant. The only known basis for estimating the phosphorus production of this plant is a report concerning the capacity of the electric power plant attached to this chemical factory. This report states that the electric power capacity of this plant was 5,000 to 10,000 kw in 1944. Assuming that this power plant operated at maximum capacity for 10.000 hours per year, the annual output of electricity would have been about 60 million kwh. Assuming further that not more than 55 to 60 percent of the available electric power was devoted to production of phosphorus and using an electric power consumption figure of 17,000 kwh per metric ton of phosphorus as reported in a 1949 Soviet textbook, the output of phosphorus at this plant in 1944 probably would not have exceeded 2,000 metric tons per year. Since production of phosphorus at this plant has not been reported since 1946, it is possible that production is taking place at the present time (1953).

b. Production of Other Phosphorous Compounds. 66/

Phosphate, fertilizers, primarily diphosphates (precipitate), and superphosphate.

4. Military Activities. 67/

During World War II this plant discontinued the production of phosphate fertilizers and produced primarily phosphorus for military purposes.

5. Plant Equipment.

No information.

6. Source of Power. 68/

A power plant is located 45 km south of Aktyubinsk with a capacity of 5,000 to 10,000 kw. The source of energy is coal (consumption, 120 tons per day). Equipment includes 2 turbogenerators and 4 boilers.

7. Raw Materials.

1. Phosphate Rock. 69/

The plant has its own phosphorite mines, which began operations in 1934 and which have been expanded since the Second Five Year Plan (1933-37). Phosphorite deposits are located between the railroad stations of Bish-Tamak and Dzhurun in Aktyubinsk Oblast. The reserves in this area are estimated to be at least 200 million tons of phosphorite, containing up to 25 percent phosphorus pentoxide.

2. Coke.

No information.

3. Silica.

No information.

8. Storage of Phosphorus.

No information.

9. Distribution of Phosphorus.

No information.

B. Desyatiletiye Oktyabrya Khrompik Chemical Combine.

1. Location.

Pervoural'sk, Sverdlovsk Oblast, Urals (Region VIII).

2. Estimated Production of Phosphorus in 1953.

500 to 5,000 metric tons per year.

3. Production Information.

a. Production of Phosphorus. 70/

The production of phosphorus at this plant is reported by several sources of prewar or early World War II (1942)

date, and in amounts varying from 500 to 5,000 metric tons per year. No information on postwar production of phosphorus at this plant is available. It is possible that phosphorus is produced there at the present time and at the same rate.

b. Production of Other Phosphorous Compounds.

No information.

4. Military Activities.

No information.

5. Plant Equipment.

No information.

6. Source of Power.

From Chegres central power plant and from Uralenergo via transformer station 12.

7. Raw Materials.

No information.

8. Distribution of Phosphorus.

No information.

9. Storage of Phosphorus.

No information.

C. NKVD Kombinat.

1. Location.

Aktyubinsk, Aktyubinsk Oblast, Kazakh SSR (Region Xa).

2. Available Information. 72/

Red phosphorus and some highly secret products are reportedly produced at this plant, located 7 km outside the city.

D. Bersol Chemical Plant (Powder Factory No. 15).

1. Location.

Chapayevsk, Kuybyshev Oblast, Volga (Region VI).

2. Available Information. 73/

Chemical warfare agents, smoke shells, and smoke pots are reported to be produced at this plant. Power reportedly is supplied by a power plant of 7,500 kw capacity.

E. Stalin Electrochemical Combine.

1. Location.

Chirchik, Tashkent Oblast, Central Asia (Region Xb).

2. Available Information. 74/

Producing phosphorus or phosphorus fertilizers, such as superphosphate (source is not clear), and nitrogenous fertilizers, reportedly sufficient for Uzbek agriculture.

F. (Two Names, Not Reported).

1. Location.

Rudnichnyy, Kirov Oblast, Central European USSR (Region VII).

2. Available Information. 75/

One phosphorus-processing plant is reportedly located here, about 20 km northeast of the Fosforitnaya railroad station. Another phosphorus works is reported southwest of Fosforitnaya. The large nearby Vyatka-Kama phosphorite deposits make it possible that phosphorus might be produced here.

G. ATZ Chemical Plant.

1. Location.

Gorlovka, Stalino Oblast, Ukraine (Region III).

2. Available Information. 76/

One building which contained furnaces was believed to be producing phosphorus.

H. (Name Not Reported).

1. Location.

Kandalaksha, Murmansk Oblast, Northwest (Region Ia).

2. Available Information. 77/

Phosphorus, phosphoric acid, and superphosphates from apatite were reportedly produced here. Production of phosphorus at this location seems possible in view of the proximity of the plant to large deposits of apatite ore at Kirovsk and because of the availability of electric power.

I. Bogoslovsk Metallurgical and Chemical Combine.

1. Location.

Karpinsk, Sverdlovsk Oblast, Urals (Region VIII).

2. Available Information. 78/

Phosphorus was reported to be produced at this plant by German intelligence reports, one of which mentioned a planned production of 50 metric tons per year.

J. (Name Not Reported, Presumed to Be "Raketa" Explosives Plant).

1. Location.

Kemerovo, Kemerovo Oblast, West Siberia (Region IX).

2. Available Information. 79/

A phosphorus plant was reported, which was located 6.5 km north of the city, on the east bank of Tom' River, and north of an electric power plant.

K. Frunze Chemical Combine.

1. Location.

Kineshma, Ivanovo Oblast, Central European USSR (Region VII).

2. Available Information. 80/

Phosphorus, phosphoric acid, and incendiary projectiles have reportedly been produced here. Phosphorite deposits, estimated at 9.9 million metric tons, of which only 116,000 metric tons have been mined, are found in the Kineshma region.

L. State Institute of Applied Chemistry (GIPKh) (Formerly "Vatny Ostrov" Chemical Plant).

1. Location.

Leningrad, Leningrad Oblast, Northwest (Region Ia).

2. Available Information. 81/

Both white and red phosphorus, phosphoric acid, and smoke and incendiary materials were reportedly produced here in 1928-29. The electrothermal production of phosphorus from phosphorites and apatites was reportedly developed at this institute.

M. "Liskhimstroy" Chemical Combine.

1. Location.

Lisichansk, Voroshilovgrad Oblast, Ukraine (Region III).

2. Available Information. 82/

Phosphorus is listed among the chemical warfare products made at this plant.

N. Eesti Phosphorit Works.

1. Location.

Maardu (near Tallin), Estonian SSR, Baltic (Region IIa).

2. Available Information. 83/

Although a "phosphorus" plant was reportedly built at this site in 1941, and both phosphorite fertilizer and phosphorus were reportedly produced, there is no convincing evidence that this plant ever produced phosphorus. The plant apparently was built to produce superphosphate fertilizer. Reports of large shipments of "phosphorus" to Germany quite probably referred to shipments of phosphorus fertilizer. In view of the availability of local phosphate rock deposits, it is conceivable that phosphorus might be produced at this plant in the future.

O. Kislotnoye Ordzhonikidze Superphosphate Plant (Chemical Plant No. 90).

1. Location.

Molotov, Molotov Oblast, Urals (Region VIII).

2. Available Information. 84/

Phosphorus and sulfuric acid reportedly have been produced here since the beginning of World War II.

P. (Name Not Reported).

1. Location.

Riga, Latvian SSR, Baltic (Region IIa).

2. Available Information. 85/

Located 4 km north of Riga, on the east shore of the Dvina River. This plant received an unknown type of grey powder (possibly apatite) in open railroad freight cars and produced phosphorus and sulfuric acid. Approximately

15 freight cars of 20-ton capacity and 5 freight cars of 50-ton capacity of end products reportedly were shipped daily to an unknown destination.

Q. Voykhim Zavod Lenin.

1. Location.

Saratov, Saratov Oblast, Volga (Region VI).

2. Available Information. 86/

Phosphorus and phosphorus-halogen compounds are reportedly produced at this plant. During World War I this plant supplied the entire military needs of the Tsarist armed forces for chlorine. The plant has since gone through many large-scale improvements and modernizations.

R. (Name Not Reported).

1. Location.

Shostka, Sumy Oblast, Ukraine (Region III).

2. Available Information. 87/

Production of red and white phosphorus was reported at a large chemical plant located about 1 mile south of Shostka. The principal end products reportedly were smokeless powder and nitroglycerin.

S. Chemical Combine (Powder and Explosives Plant).

1. Location.

Vologda, Vologda Oblast, Northern European USSR (Region Ib).

2. Available Information. 88/

The phosphorus production planned for 1937 was reported to be 2,000 metric tons yearly, but this figure appears to be high and doubtful in view of the lack of any further confirmatory information.

T. Kuybyshev Chemical Combine.

1. Location.

Voskresensk, Moscow Oblast, Central European USSR (Region VII).

2. Available Information. 89/

Phosphorus is mentioned among the products made by this plant. This plant is known to manufacture superphosphate. In view of the existence

of the large Yegor"yevsk phosphorite deposits in this region, it is conceivable that phosphorus might be produced here.

U. (Name Not Reported).

1. Location.

Vurnary, Chuvash ASSR, Volga (Region VI).

2. Available Information. 90/

The production of phosphorus is reported at a chemical plant manufacturing phosphate meal and other chemicals from the local phosphorite and oil shale deposits.

V. Troitsk Phosphorus Factory.

1. Location.

Zolotaya Sopka, Chkalov Oblast, Urals (Region VIII).

2. Available Information. 91/

Production of 2,000 kg of phosphorus was reported for 1923-24. This factory is said to have produced glue, various soaps, and red phosphorus. It is not known whether the plant is still in operation.

W. (Name Not Reported).

1. Location.

Rechitsa, Gomel Oblast, Belorussian SSR (Region IIb).

2. Available Information. 92/

A phosphorus plant which has pledged preliminary fulfillment of the Fourth Five Year Plant (1946-50) is mentioned in an unconfirmed Soviet press report.

APPENDIX B

METHODOLOGY

I. Estimating Total Soviet Production.*

Total Soviet production of phosphorus was arrived at by adding to the estimated production of individual known or possible plants the former productive capacity of the German phosphorus plant dismantled at Piesteritz.

Because of the many uncertainties existing in the information available on the production of individual plants and the total lack of information regarding Soviet requirements for phosphorus, reporting has been done in terms of an estimated production range, consisting of a minimum estimate, a best estimate, and a maximum estimate.

The estimates given in this report are intended to represent production. They are believed also to represent practical working capacity. The information, however, is not sufficiently detailed to make a clear-cut distinction between production and capacity.

Total plant-by-plant estimates of the production of phosphorus in the USSR for 1953 is shown in Table 8.**

It will be noted that in the minimum estimate only the Dzerzhinsk and Beketovka plants and the capacity dismantled from Piesteritz are included. These production facilities are believed to be the minimum now installed in the USSR. In the best estimate, additional production facilities are estimated for Berezniki, Kirovsk, and Pervoural'sk. The information upon which estimates for these latter plants is based appears to be adequate but not as sound as the information concerning the former plants. The maximum estimate also includes the Alga plant, which is reported to have converted from production of phosphate fertilizer to production of phosphorus during the war. The maximum estimate also uses the higher estimate of individual plant production wherever a production range was reported.

II. Estimating Input Requirements.***

The method used in estimating the amounts of raw materials and electricity required by the USSR in the production of phosphorus was to multiply Soviet consumption factors required for the production of 1 metric ton of phosphorus by the best estimate of total Soviet phosphorus production (35,500 metric tons).

* See II, C-1, p. 11, above.
** Table 8 follows on p. 35.
*** See II, D, p. 12, above.

Table 8

Plant-by-Plant Estimates for the Production of Phosphorus in the USSR
1953

Metric Tons

Plant	Estimates: Best	Maximum	Minimum
Dzerzhinsk	4,800	4,800	4,800
Beketovka	2,700	7,600	2,700
Piesteritz a/	18,000	20,000	18,000
Berezniki	4,500	4,500	
Kirovsk	5,000	5,000	
Pervoural'sk	500	5,000	
Alga		2,000	
Total	35,500	48,900	25,500

a. Present location of this former German plant is not known.

The consumption factors for phosphate rock, silica, coke or anthracite, and electric power were taken from a Soviet textbook. The consumption factor for carbon electrodes was obtained from a US textbook, since no corresponding factor could be found in Soviet textbooks.

III. Estimating Soviet Military Requirements.*

The estimated phosphorus requirement of 7,000 metric tons, given in Table 6,** for such purposes as the filling of munitions and for tracer shells, is based solely on parallel US military requirements which were reported to be 7,000 short tons in 1951, increasing to 17,000 short tons annually beginning in July 1952. 93/ It has been assumed that Soviet requirements for military purposes in 1952, exclusive of the requirement for nerve gases, will be slightly higher than the US requirement in 1951.

The phosphorus requirements given in Table 6 for nerve-gas production are CIA estimates.

* See III, A, p. 15, above.
** P. 15, above.

IV. Estimating Soviet Industrial Requirements.*

The best estimate of total Soviet phosphorus production is 35,500 metric tons. Subtracting estimated military requirements (see Table 6) of 9,900 metric tons leaves 25,600 metric tons, estimated industrial use.

In the US about 90 percent of phosphorus production goes into phosphoric acid. Assuming this percentage holds true for the USSR, 23,040 metric tons would go into this use. This is equivalent to 17 percent of estimated US phosphorus consumption for this purpose in 1952.

Soviet match production is assumed to be about 50 percent of US match production. The latter currently consumes about 2,400 metric tons of phosphorus annually. 94/

Soviet phosphorus requirements for the manufacture of phosphorus pentoxide and phosphorus trichloride were calculated by subtracting the phosphorus requirements for matches and phosphoric acid from the total estimated phosphorus available for industrial uses.

V. Estimating Production of Individual Plants.**

In general, estimates of production in the individual plants listed in Appendix A were based either on published figures or were derived from information as to available electric power or on reported phosphate rock shipments to the plant. In some instances, where different production figures and different shipments of phosphate rock were given by various sources, an estimated production range was assigned to that plant.

* See III, B, p. 16, above.

** See Appendix A, p. 18, above.

APPENDIX C

GAPS IN INTELLIGENCE

Very little is known regarding the following aspects of the Soviet phosphorus industry:

1. Actual production, particularly since 1949.

2. The number of plants engaged in its manufacture.

3. Details of plant equipment, such as number and type of electric furnaces, capacity, and power consumption.

4. Source and amount of phosphate rock, coke, and silica consumed by individual plants.

5. Amounts of phosphorus allocated to various commercial end-use industries. Amounts used for munitions filling, for nerve-gas manufacture, and for other military uses.

6. Location of the reassembled German phosphorus furnaces which were dismantled from Piesteritz in 1946. Degree of present utilization of these production facilities.

7. Production of phosphorus-derived chemicals, from which accurate estimates of phosphorus consumption in peacetime could be derived.

8. Stockpiling of phosphorus. Location and size of stockpiles.

APPENDIX D

SOURCES AND EVALUATION OF SOURCES

1. Evaluation of Sources.

The sources used in this report can be divided roughly into three categories as follows:

1. Air Force, Navy, State, and a few CIA reports (OO and SO sources), mostly based on interrogation of German prisoners of war repatriated from the USSR who had been working in various Soviet industrial plants. A few sources in this class are based on reports of US diplomats or engineers who had visited the USSR.

2. Captured German intelligence documents, describing Soviet chemical plants, types of products manufactured, and natural resources.

3. Soviet and US chemical textbooks and publications.

Sources belonging to the first category were primarily used in the detailed plant studies (Appendix A). These, together with captured German documents (SDS reports), provided the backbone of the plant studies. An evaluation of these sources as to the reliability of the information supplied by them is somewhat difficult. The German intelligence documents provided most of the production figures, which although about 10 to 15 years old, can be considered as fairly reliable. The remainder of the report is almost entirely based on accounts of returning German prisoners of war. These individuals had seldom been allowed access to important production details. Although the information supplied by them is of fairly recent date (up to late 1949), the reliability and even the veracity of these prisoner-of-war accounts are rather doubtful. A large number of SO reports were studied. They proved to be of considerable value for the many technical details which they clearly presented.

The third category of references, namely Soviet and US textbooks and publications, were relied on primarily in the chapters on the general description of the nature and uses of phosphorus, the history of phosphorus production in the USSR, technology, raw materials and power requirements, and estimated Soviet consumption of phosphorus in 1952. US data on the operational details of phosphorus technology were used only when no corresponding Soviet figures could be found.

2. Sources.

1.

2. S.I. Vol'fkovich, Obschaya khimicheskaya tekhnologiya (General Chemical Technology), Vol. II, Moscow-Leningrad, 1946, p. 226. U.
3. Ibid.
4. CIA OO. 24 May 1949 (date of information, 1947). S,

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